Snap-Shots on Neuroinformatics and Neural Information Processing Research in Singapore

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Abstract. This paper summarizes some of the key research areas in neuroinformatics and neural networks that have recently been or are being carried out in Singapore. Researchers in Singapore have been proposing novel algorithms for various neural networks, i.e., radial basis function networks, fuzzy neural networks, multilayer perceptrons, and support vector machines. Neural networks have been applied to solving a wide variety of difficult problems in bioinformatics, multimedia, data mining, and communications. Researchers in Singapore are also working with neurophysiologists on functional brain imaging, brain atlases, and brain disease analysis.

Keywords: RBF, fuzzy, neural network, brain, neuroinformatics

1 Introduction

Despite its small geographical size, Singapore has been making significant contributions to the research and development in neuroinformatics and neural networks over the past decades. Active research are being carried out in many fronts, including novel neural network algorithms, applications of neural networks, as well as investigations in functional brain imaging, brain atlases, and brain disease analysis.

Most of the academic research activities concentrate in the two major universities in Singapore, that is, the National University of Singapore (NUS) and the Nanyang Technological Unviersity (NTU), whereas a number of national research institutes (RIs) mainly carry out applied research. The Agency for Science, Technology, and Reasearch (A*STAR) is the main source of scientific and technological research funding in Singapore, and manages all national RIs in Singapore. A number of RIs are active in neural network and related research, especially Singapore Institute of Manufacturing Technology (SIMTech), the Institute of Infocomm Research (I^2R), and the BioInformatics Institute (BII). The Ministry of Education also funds a part of the research in the two universities, for example, with funding to cover scholarships for graduate students.

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As suggested by its title, the present paper by no means reflects an exhaustive collection of *all* research activities in neuroinformatics and neural networks in Singapore.

2 Proposing Novel Neural Network Algorithms

Researchers at the NTU Neural Network Research Group (NNRG) led by Lipo Wang have recently developed an importance ranking technique called "separability-correlation measure" [1] for feature selection. After eliminating irrelevant input features, the complexity of a classifier can be reduced and the classification performance improved. They also proposed a modified method for efficient construction of an RBF classifier [1], by allowing for large overlaps between clusters corresponding to the same class label. This approach significantly reduces the structural complexity of the RBF network and improves the classification performance.

The NNRG also proposed a noisy chaotic neural network, which combines the best properties of conventional simulated annealing and efficient chaotic search [2]. They have successfully applied this method to a variety of optimization problems, such as broadcast scheduling in packet radio networks, channel assignment in mobile communications [3], noisy and blurred image restoration, and image segmentation [4].

Lu and Rajapakse at the NTU School of Computer Engineering incorporated constraints or prior knowledge into learning algorithm while improving independent component analysis (ICA). They have developed a method to eleminate indeterminacy in ICA [6]. Further, they have developed the ICA with Reference (ICA-R) to incorporate input stimuli in fMRI experiments into the analysis directly.

Phua and Ming at the NUS Department of Computer Science proposed the use of parallel quasi-Newton (QN) optimization techniques to improve the rate of convergence of the training process for multilayer perceptron (MLP) neural networks [7]. Simulations with nine benchmark problems show that the proposed algorithms outperform other existing methods. Guan and Li [8] at the NUS Department of Electrical and Computer Engineering proposed a method to divide the original problem into a set of subproblems, each of which is composed of the whole input vector and a fraction of the output vector. By means of a monotonic transformation, Toh [5] at the I^2R derived a sufficient condition for global optimality of a network error function, based on which a penalty-based algorithm was derived directing the search towards possible regions containing the global minima.

Lee, Keerthi, Ong, and DeCoste [10] from the NUS Mechanical Engineering Department proposed an efficient method for computing the leave-one-out (LOO) error for support vector machines (SVMs) with Gaussian kernels quite accurately. The new method often leads to speedups of 10C50 times compared to standard LOO error computation. Keerthi [9] proposed an efficient iterative techniques for computing radius and margin in SVMs.

3 Applications of Neural Networks

LimSoon Wong, Valdimir Brusic, Vladimir Brajic, and Li Jinyang of the Knowledge Discovery Group of the I^2R used neural networks for a number of bioinformatics applications, such as prediction of immunogenic peptides [25] and recognition of promoters [26]. In addition, they have used neural networks to find translation initiation sites and transcription start sites from genomic sequences.

Lo and Rajapakse combined hidden Markov models (HMMs) and neural networks in order to capture compositional properties of complex genes with minimal error rate and high correlation coefficient. Splice site detection was also examined by a higher-order Markov model implemented with a neural network [17].

Wang et al are applying novel feature selection techniques and a dynamically-generated fuzzy neural network [18][19] that they proposed earlier to cancer classification with microarray gene expression data. They [20] were able to obtain highly accurate results using a much smaller number of genes compared to other results reported in the literature. It is useful to reduce the number of genes required for cancer classification because: (a) it means lighter computational burden and lower "noise" arising from irrelevant gene data; (b) in some cases it even becomes possible to extract simple rules for doctors to make accurate diagnosis without the need for any classifiers; (c) it can simplify gene expression tests to include only a small number of genes rather than thousands of genes, which may bring down the cost for cancer testing; and (d) it calls for further investigations into possible biological relationship between these small numbers of genes and cancer developmenttreatment.

Corne, Fogel, Rajapakse, and Wang are editing a special issue for the Soft Computing journal on "Soft Computing for Bioinformatics and Medical Informatics", featuring several novel neural network applications.

Cao and Tay [11] from the NUS Mechanical Engineering Department applied SVMs to financial time series prediction. Five real futures contracts collated from the Chicago Mercantile Market were used as the data sets. Song et al from the NTU School of Electrical and Electronic Engineering [22] applied a robust SVM for bullet hole image classification.

Wang edited a book titled "Support Vector Machines: Theory and Applications" to be published by Springer-Verlag in 2004 [12]. This book consists of about 20 chapters contributed by active researchers in the SVM area covering the most recent advances in both theoretical studies and SVM applicaions to a variety of challenging problems. A recent book edited by Rajapakse and Wang [13] entitled "Neural Information Processing: Research and Development" includes numerous examples on latest models and applications of neural networks. Two edited volumes by Halgamuge and Wang concentrate on recent work on clustering, prediction, and data mining [14][15]. Another book [16] covers a range of neural network applications to multimedia processing, including image and video processing.

Zhang et al [31] of the Media Division of I^2R recently developed a high performance face recognition system by combining Gabor wavelet networks for visual pattern representation and kernel associative memories for nonlinear concept learning. Werner et al [32] of the Communication and Devices Division proposed a neural network approach for adaptive routing in dynamic topology networks, e.g., LEO satellite networks and mobile ad hoc networks. Suganthan at the NTU School of Electrical and Electronic Engineering used [21] self-organizing maps for shape indexing.

K.K. Tan and colleagues at the Department of Electrical and Computer Engineering at the NUS developed neural network-based nonlinear controllers and tested these controllers in simulation and laboratory work. Excellent performance and transient response under different operating conditions were established. These controllers will be applied in the power electronic industry [23].

Srinivasan leads a three-year project applying neural networks to real-world electrical load forecasting. Neural network-based prediction models have also been developed for congestion prediction in dynamic street traffic network [24]. As the traffic patterns vary from day to day, a classifier is used to group the input data into a number of clusters. Feedforward neural networks are then individually tuned to specify the input-output relationship for each cluster. The neural network architecture is optimized using evolution algorithms. Another funded project involves development, simulation and testing of neural network-based systems for incident detection and network re-routing for traffic networks. A novel constructive probabilistic neural network has been developed and excellent performance on real data obtained from Singapore expressways has been obtained.

4 Research in Neuroinformatics

The Biomedical Imaging Lab of BII, led by Wieslaw Nowinski, carries out research and development in a variety of areas, including construction of anatomical, functional and vascular brain atlases; development of atlas-based applications for neurosurgery, neuroradiology, human brain mapping [27]; rapid and automated brain segmentation based on domain knowledge and image processing [28] [29]; identification and localization of brain pathology; multi-modal and model-to-data registration; geometric and physical modeling; brain databases, and virtual reality in brain intervention. BII has constructed the Cerefy Brain Atlas Database with gross anatomy, brain connections, subcortical structures, and sulcal patterns containing 1,000 structures and 400 sulcal patterns.

Neuroinformatics lab at I^2R, led by Guan Cuntai, focuses on the investigation and development of effective mathematical framework and learning algorithms for the analysis of brain signals, with emphasis on EEG (electroencephalographic) signal.

The NTU neuroinformatics group concentrates on the analysis of both structural and functional MRI in order to segment different tissue classes of the brain or identify subcortical structures of the brain. They developed techniques for the detection of activation from functional MR images and modeling human brain surface by active NURBS surfaces [30].

5 Conclusions

Despite the small geographic size and the absence of national consorted programs in neuroinformatics or neural networks like those in Japan, Korea, and China, there has been very active research in both neuroinformatics and neural networks in Singapore. We expect that these efforts will continue in the future and more exciting research results will be reported by researchers from Singapore.

References

1. Fu, X., Wang, L.: Data Dimensionality Reduction with Application to Simplifying RBF Network Structure and Improving Classification Performance. IEEE Transactions on System, Man, Cybern, Part B - Cybernetics, Vol. 33. (2003) 399–409
2. Wang, L., Li, S., Tian, F., Fu, X.: A Noisy Chaotic Neural Network for Solving Combinatorial Optimization Problems: Stochastic Chaotic Simulated Annealing. IEEE Trans. System, Man, Cybern, Part B - Cybernetics (2004)
3. Wang, L.: Soft Computing in Communications. Springer-Verlag, Berlin (2003) 131–145
4. Yan, L., Wang, L., Yap, K.H.: A noisy chaotic neural network approach to image denoising. Proc. IEEE Intern. Conf. Image Processing (2004)
5. Toh, K.A.: Deterministic Global Optimization for FNN Training. IEEE Trans. Systems, Man and Cybernetics, Part B, Vol. 33 (2003) 977 - 983
6. Lu., W., Rajapakse, J.C.: Eleminating Indeterminacy in ICA. Neurocomputing, Vol. 50 (2003) 271–290
7. Phua, P.K.H., Ming, D.: Parallel Nonlinear Optimization Techniques for Training Neural Networks. IEEE Trans. Neural Networks, Vol. 14 (2003) 1460–1468
8. Guan, S., Li, S.: Parallel Growing and Training of Neural Networks Using Output Parallelism. IEEE Trans. Neural Networks, Vol. 13 (2002) 542–550
9. Keerthi, S.S.: Efficient Tuning of SVM Hyperparameters Using Radius/margin Bound and Iterative Algorithms. IEEE Trans. Neural Networks, Vol. 13. (2002) 1225–1229
10. Lee., M.M.S., Keerthi, S.S., Chong., J., DeCoste, D.: An Efficient Method for Computing Leave-one-out Error in Support Vector Machines with Gaussian Kernels. IEEE Transactions on Neural Networks, Vol. 15 (2004) 750–757
11. Cao, L.J., Tay, F.E.H.: Support Vector Machine with Adaptive Parameters in Financial Time Series Forecasting, IEEE Trans. Neural Networks, Vol. 14 (2003) 1506–1518
12. Wang, L.: Support Vector Machines: Theory and Applications. Springer-Verlag (2004)
13. Rajapakse, J.C., Wang, L.: Neural Information Processing: Research and Development. Springer-Verlag (2004)
14. Halgamuge, S., Wang, L.: Computational Intelligence for Modelling and Predictions. Springer-Verlag (2004)
15. Halgamuge, S., Wang, L.: Classification and Clustering for Knowledge Discovery, Springer-Verlag (2004)
16. Tan, Y.P., Yap, K.H., Wang, L.: Intelligent Multimedia Processing with Soft Computing. Springer-Verlag (2004).
17. Ho, S.L., Rajapakse, J.C.: Splice Site Detection with a Higher-order Markov Model Implemented on a Neural Network. Genomic Informatics (2003)

18. Frayman, Y., Wang, L.: A Dynamically-constructed Fuzzy Neural Controller for Direct Model Reference Adaptive Control of Multi-input-multi-output Nonlinear Processes. Soft Computing, Vol. 6 (2002) 244–253
19. Frayman, Y., Wang, L.: A Fuzzy Neural Approach to Speed Control of an Elastic Two-mass System. Proc. 1997 International Conference on Computational Intelligence and Multimedia Applications (1997) 341–345
20. Liu, B., Wan, C., Wang, L.: Unsupervised gene selection via spectral biclustering. Proc. IJCNN (2004)
21. Suganthan, P.N.: Shape indexing using self-organizing maps. IEEE Trans. Neural Networks. vol.13 (2002) 835 - 840
22. Song, Q., Hu, W., Xie, W.: Robust Support Vector Machine with Bullet Hole Image Classification. IEEE Trans. Systems, Man and Cybernetics, Part C, Vol. 32 (2002) 440–448
23. Huang, S.N., Tan, K.K., Lee, T.H.: Further Results on Adaptive Control for a Class of Nonlinear Systems Using Neural Networks. IEEE Trans. Neural Networks, Vol. 14 (2003) 719–722
24. Srinivasan, D., Xin J., Cheu, R.L.: Evaluation of Adaptive Neural Network Models for Freeway Incident Detection. IEEE Trans. Intelligent Transportation Systems, Vol. 5 (2004) 1–11
25. Tatsumi T.: Mage-6 Encodes Hla-drbeta1*0401-presented Epitopes Recognized by Cd4+t Cells from Patients with Melanoma or Renal Cell Carcinoma. Clinical Cancer Research, Vol. 9 (2003) 947–954
26. Bajic, V.B., Seah, S.H.: Dragon Gene Start Finder: An Advanced System for Finding Approximate Location of the Start of Gene Transcriptional Units. Genome Research, Vol. 13 (2003) 1923–1929
27. Nowinski, W.L., Thirunavuukarasuu, A.: The Cerefy Clinical Brain Atlas. Theime (2004)
28. Xia, Y., Hu, Q., Nowinski, W.L.: A Knowledge-driven Algorithm for a Rapid and Automatic Extraction of the Human Cerebral Ventricular System from mr Neuroimages. NeuroImage, Vol. 21 (2004) 269–283
29. Hu, Q., Nowinski, W.L.: A Rapid Algorithm for Robust and Automatic Extraction of the Midsagittal Plane of the Human Cerebrum from Neuroimages Based on Local Symmetry and Outlier Removal. NeuroImage, Vol. 20 (2003) 2154–2166
30. Meegama, R.G.N., Rajapakse, J.C.: Nurbs-based Segmentation of the Brain in Medical Images. International Journal of Pattern Recognition and Artificial Intelligence, Vol. 17 (2003) 995–1009
31. Zhang, H.,Zhang, B., Huang, W., Tian, Q.: Gabor Wavelet Associative Memory for Face Recognition. IEEE Transactions on Neural Networks (2004)
32. Werner, M.: A Neural Network Approach to Distributed Adaptive Routing of Leo Intersatellite Link Traffic. VTC98. (1998) 1498–1502